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(54) **IMAGE FORMING APPARATUS AND IMAGE FORMING APPARATUS CONTROL METHOD**

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G03G 15/00 (2006.01)
G03G 15/01 (2006.01)

(52) **U.S. Cl.**
CPC ***G03G 15/5041*** (2013.01); ***G03G 15/0131*** (2013.01); ***G03G 15/5058*** (2013.01); *G03G 2215/0161* (2013.01)

(58) **Field of Classification Search**
CPC G03G 15/5041; G03G 15/0131; G03G 15/5058; G03G 2215/0161
USPC 399/49, 72
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2006/0233561 A1* 10/2006 Yamaoka 399/49
2011/0058832 A1* 3/2011 Suzuki et al. 399/49
2012/0134702 A1* 5/2012 Fujiwara 399/72

FOREIGN PATENT DOCUMENTS

JP 2006-293240 10/2006
JP 2012-022054 2/2012

* cited by examiner

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(57) **ABSTRACT**

An image forming apparatus includes a first image forming unit that forms toner images based on image data on first image carriers; a second image carrier, on which the toner images formed on the first image carriers are transferred; a second image forming unit that transfers the toner images transferred on the second image carrier onto a transfer medium; a test pattern generating unit that generates a test pattern group with a predetermine length in a moving direction of the second image carrier; and an adjusting unit that determines a method to adjust an image formation condition for the first image forming unit using the test pattern group, based on a relationship between the predetermined length and a length of an image area, in which a print image based on the image data is formed, in a sub-scanning direction corresponding to the moving direction of the second image carrier.

12 Claims, 11 Drawing Sheets

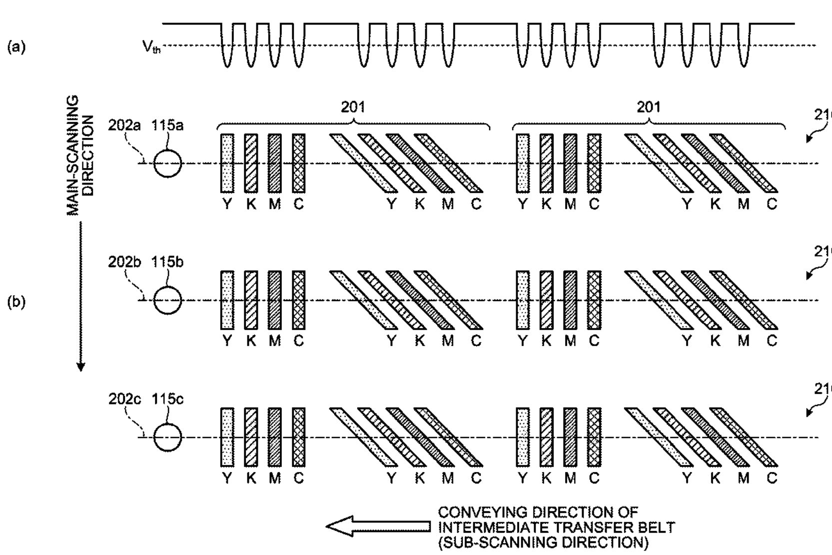


FIG.1

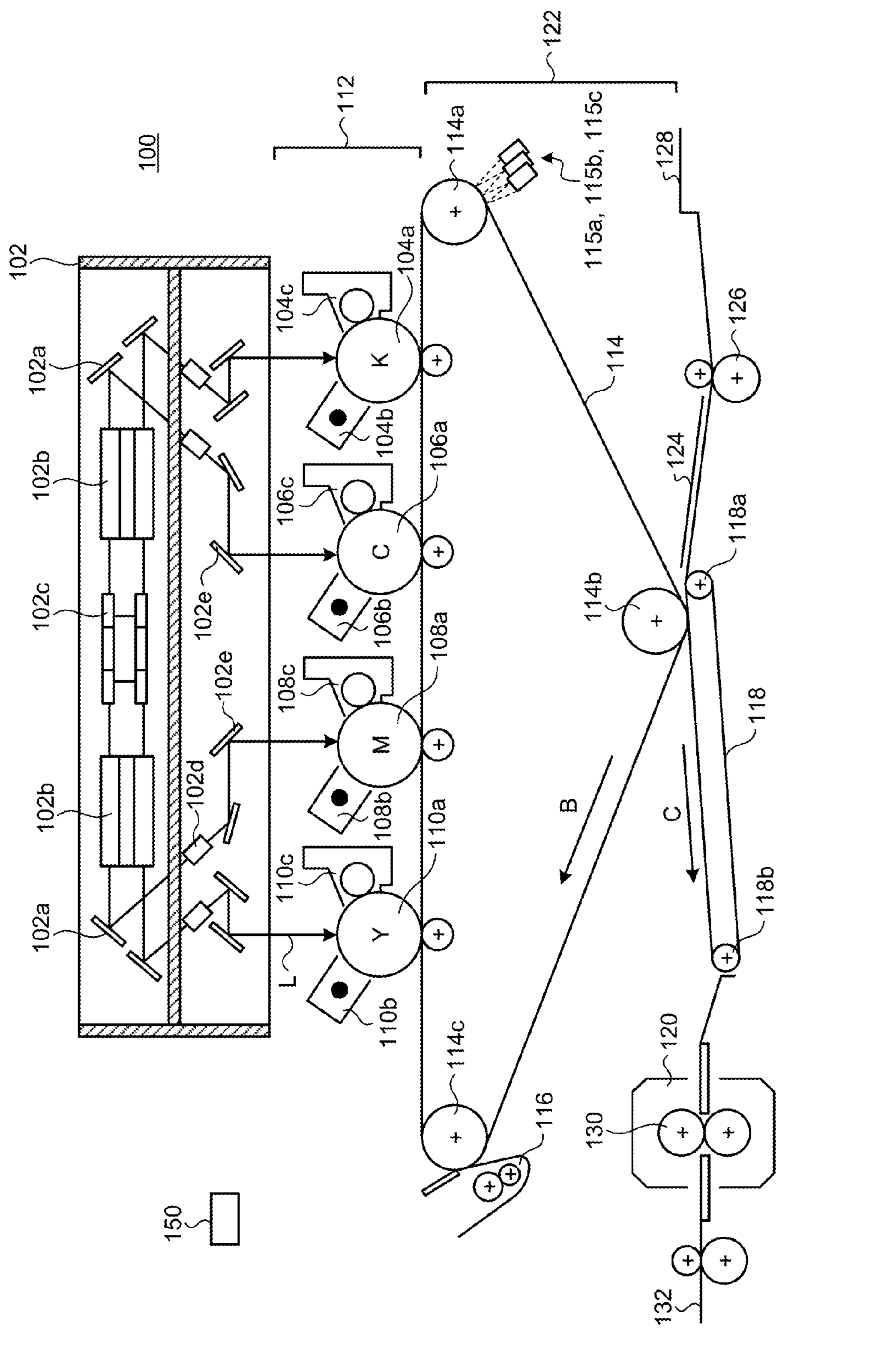

100
102
102a
102b
102c
102d
102e
104a
104b
104c
106a
106b
106c
108a
108b
108c
110a
110b
110c
K
C
M
Y
L
112
114
114a
114b
114c
115a, 115b, 115c
116
118
118a
118b
120
122
124
126
128
130
132
150
B
C

FIG.2

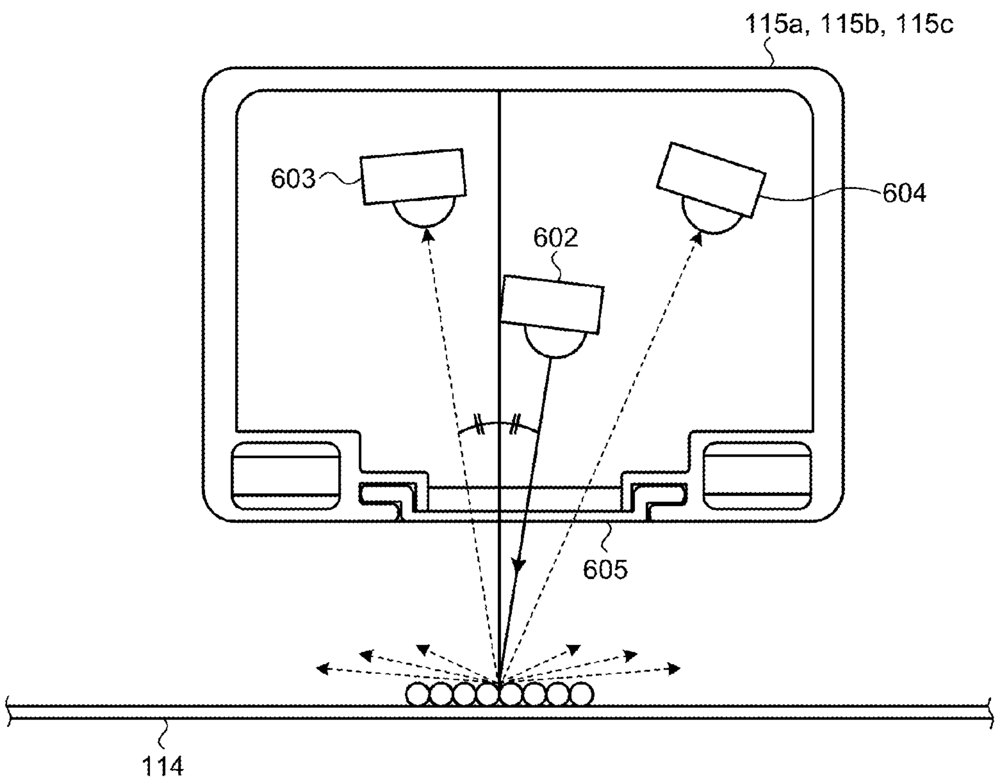


FIG.3

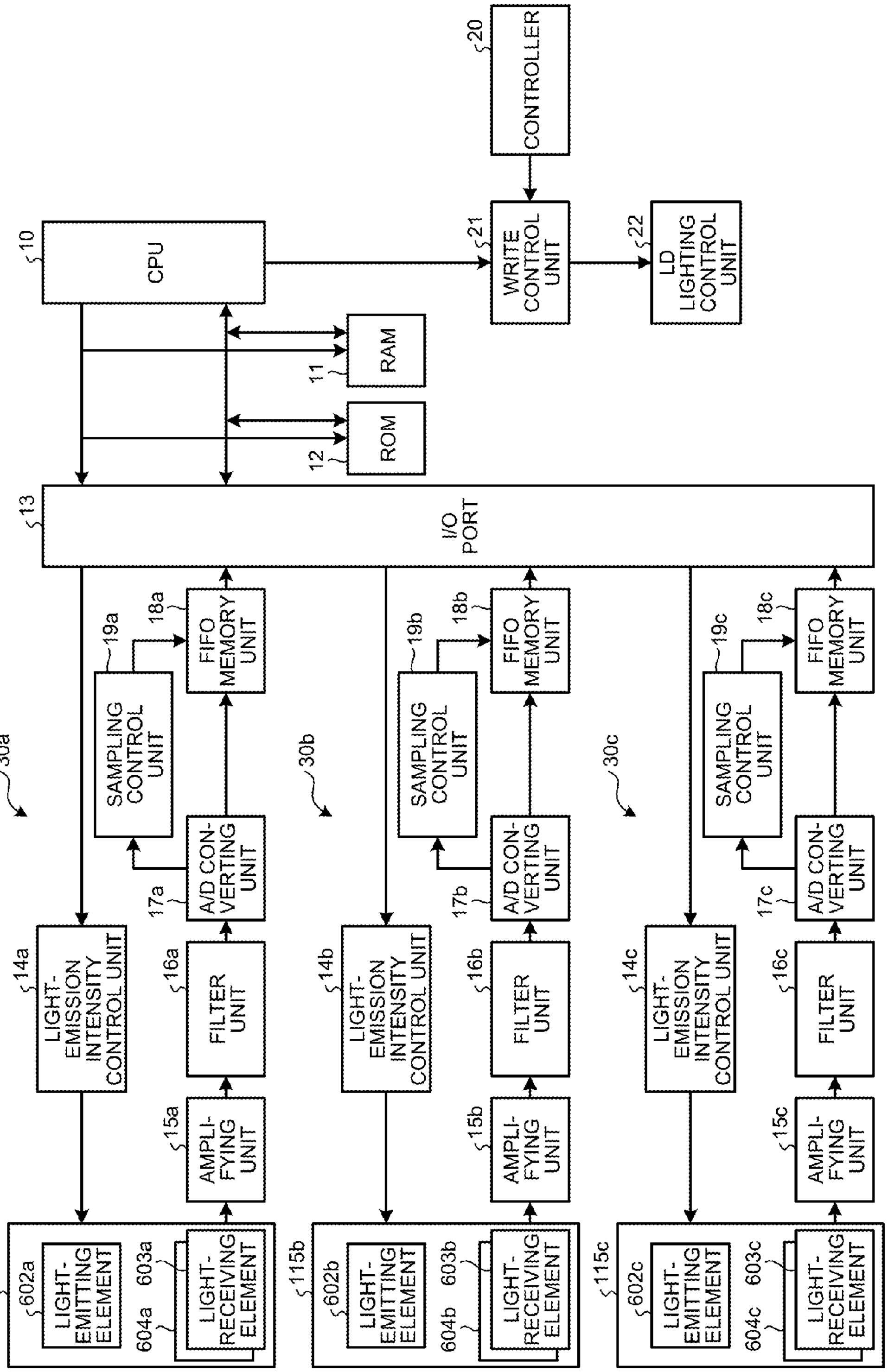
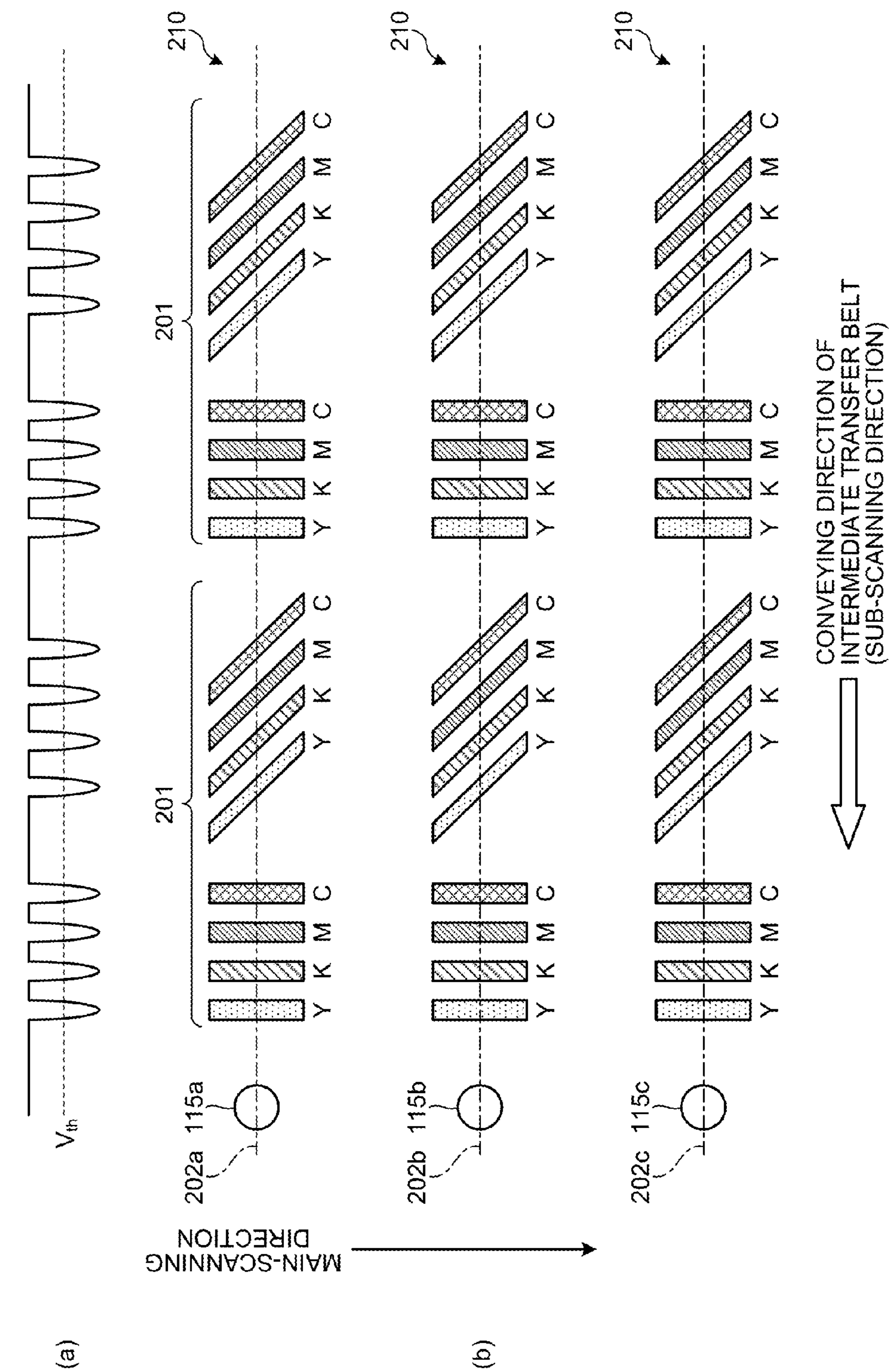

CONTROLLER
20
CPU
10
WRITE CONTROL UNIT
21
LD LIGHTING CONTROL UNIT
22
RAM
11
ROM
12
I/O PORT
13
30a
30b
30c
SAMPLING CONTROL UNIT
19a
19b
19c
FIFO MEMORY UNIT
18a
18b
18c
A/D CON-VERTING UNIT
17a
17b
17c
LIGHT-EMISSION INTENSITY CONTROL UNIT
14a
14b
14c
FILTER UNIT
16a
16b
16c
AMPLI-FYING UNIT
15a
15b
15c
LIGHT-EMITTING ELEMENT
602a
602b
602c
LIGHT-RECEIVING ELEMENT
603a
603b
603c
604a
604b
604c
115a
115b
115c

FIG.4



(a)
(b)
V_{th}
MAIN-SCANNING DIRECTION
202a
202b
202c
115a
115b
115c
201
210
Y
K
M
C
CONVEYING DIRECTION OF INTERMEDIATE TRANSFER BELT (SUB-SCANNING DIRECTION)

FIG.5

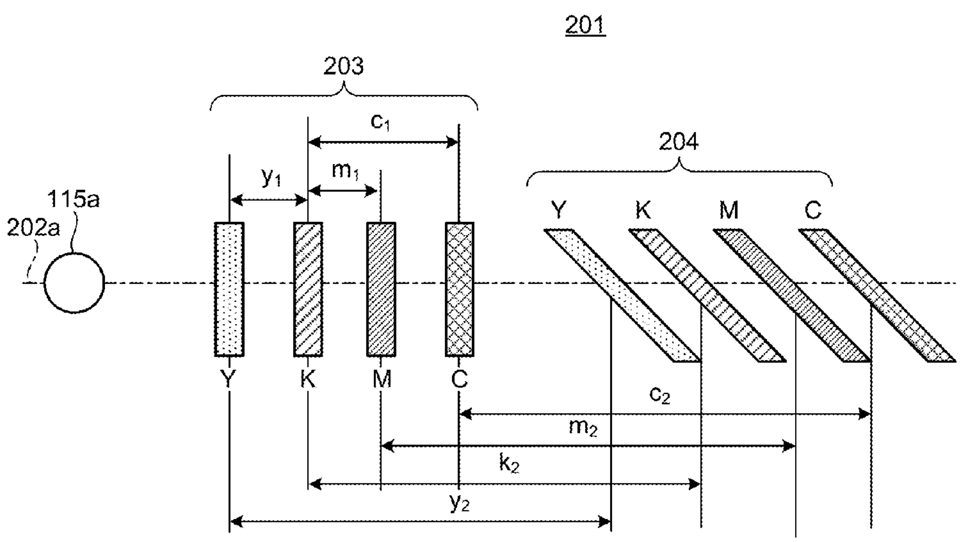


FIG.6

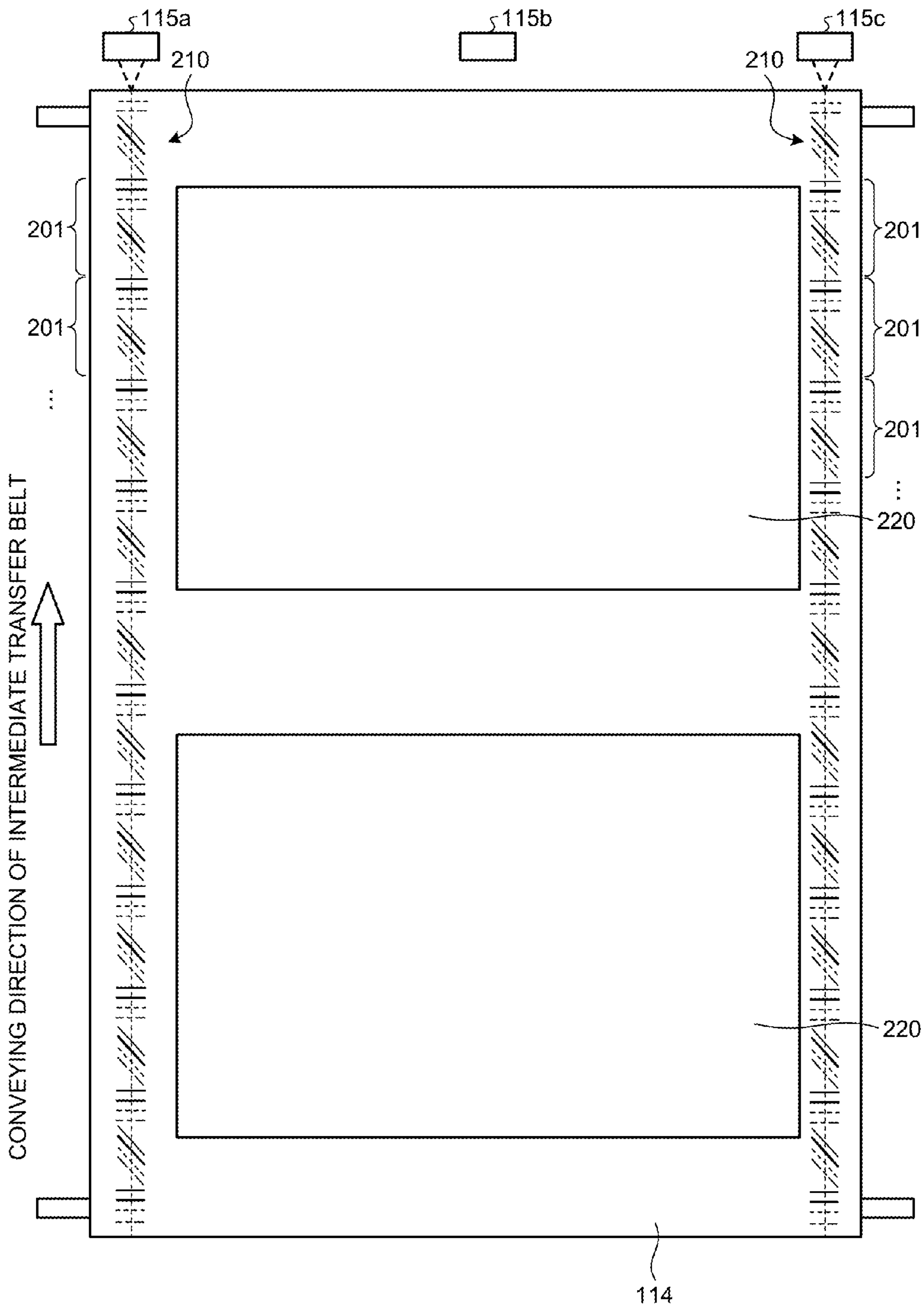
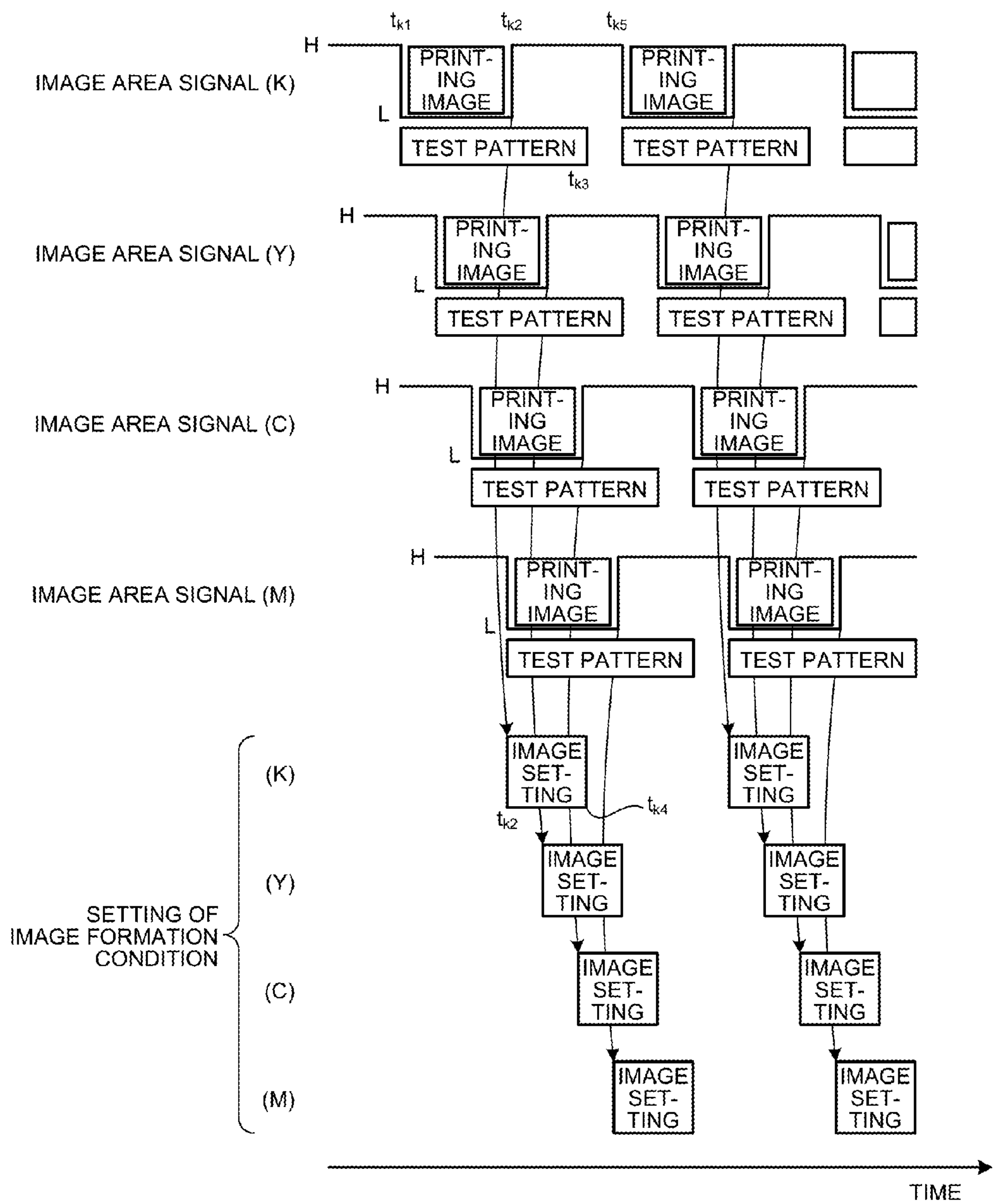
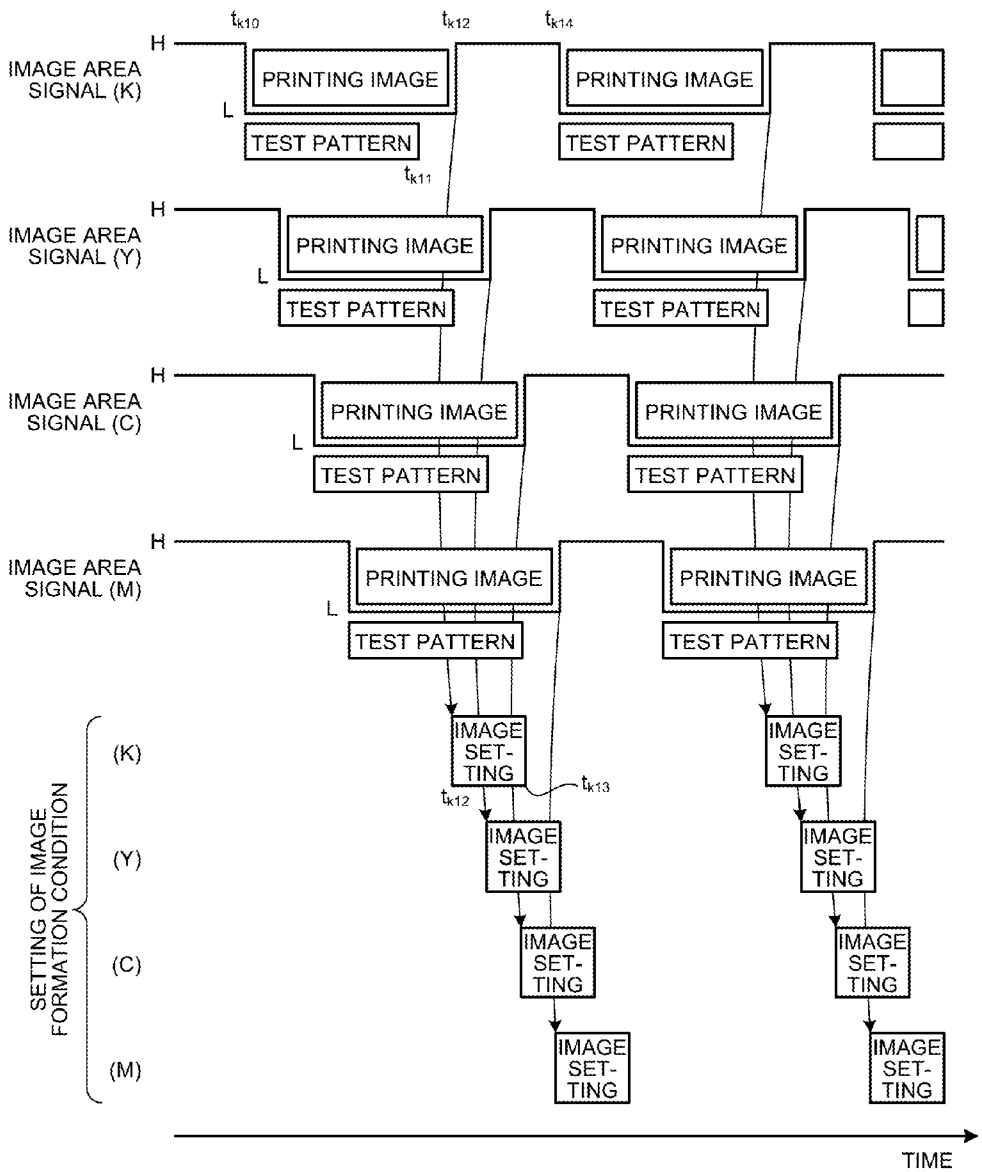

115a
115b
115c
210
210
201
201
201
201
201
220
220
114
CONVEYING DIRECTION OF INTERMEDIATE TRANSFER BELT

FIG.7



t_{k1}
t_{k2}
t_{k5}
H
L
IMAGE AREA SIGNAL (K)
PRINT-ING IMAGE
TEST PATTERN
t_{k3}
IMAGE AREA SIGNAL (Y)
IMAGE AREA SIGNAL (C)
IMAGE AREA SIGNAL (M)
SETTING OF IMAGE FORMATION CONDITION
(K)
(Y)
(C)
(M)
IMAGE SET-TING
t_{k2}
t_{k4}
TIME

FIG.8



t_{k10}
t_{k12}
t_{k14}
H
IMAGE AREA SIGNAL (K)
L
PRINTING IMAGE
PRINTING IMAGE
TEST PATTERN
TEST PATTERN
t_{k11}
H
IMAGE AREA SIGNAL (Y)
L
PRINTING IMAGE
PRINTING IMAGE
TEST PATTERN
TEST PATTERN
H
IMAGE AREA SIGNAL (C)
L
PRINTING IMAGE
PRINTING IMAGE
TEST PATTERN
TEST PATTERN
H
IMAGE AREA SIGNAL (M)
L
PRINTING IMAGE
PRINTING IMAGE
TEST PATTERN
TEST PATTERN
SETTING OF IMAGE FORMATION CONDITION
(K)
(Y)
(C)
(M)
IMAGE SET-TING
t_{k12}
t_{k13}
TIME

FIG.9

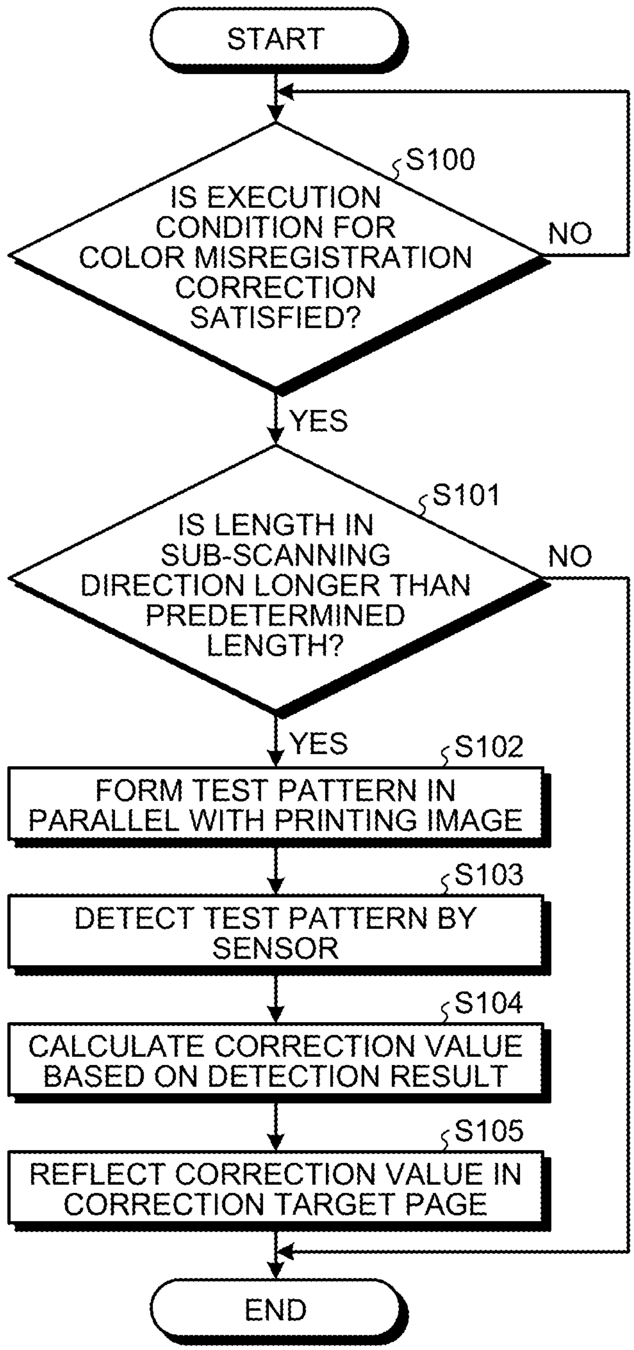

START
S100
IS EXECUTION CONDITION FOR COLOR MISREGISTRATION CORRECTION SATISFIED?
NO
YES
S101
IS LENGTH IN SUB-SCANNING DIRECTION LONGER THAN PREDETERMINED LENGTH?
NO
YES
S102
FORM TEST PATTERN IN PARALLEL WITH PRINTING IMAGE
S103
DETECT TEST PATTERN BY SENSOR
S104
CALCULATE CORRECTION VALUE BASED ON DETECTION RESULT
S105
REFLECT CORRECTION VALUE IN CORRECTION TARGET PAGE
END

FIG.10

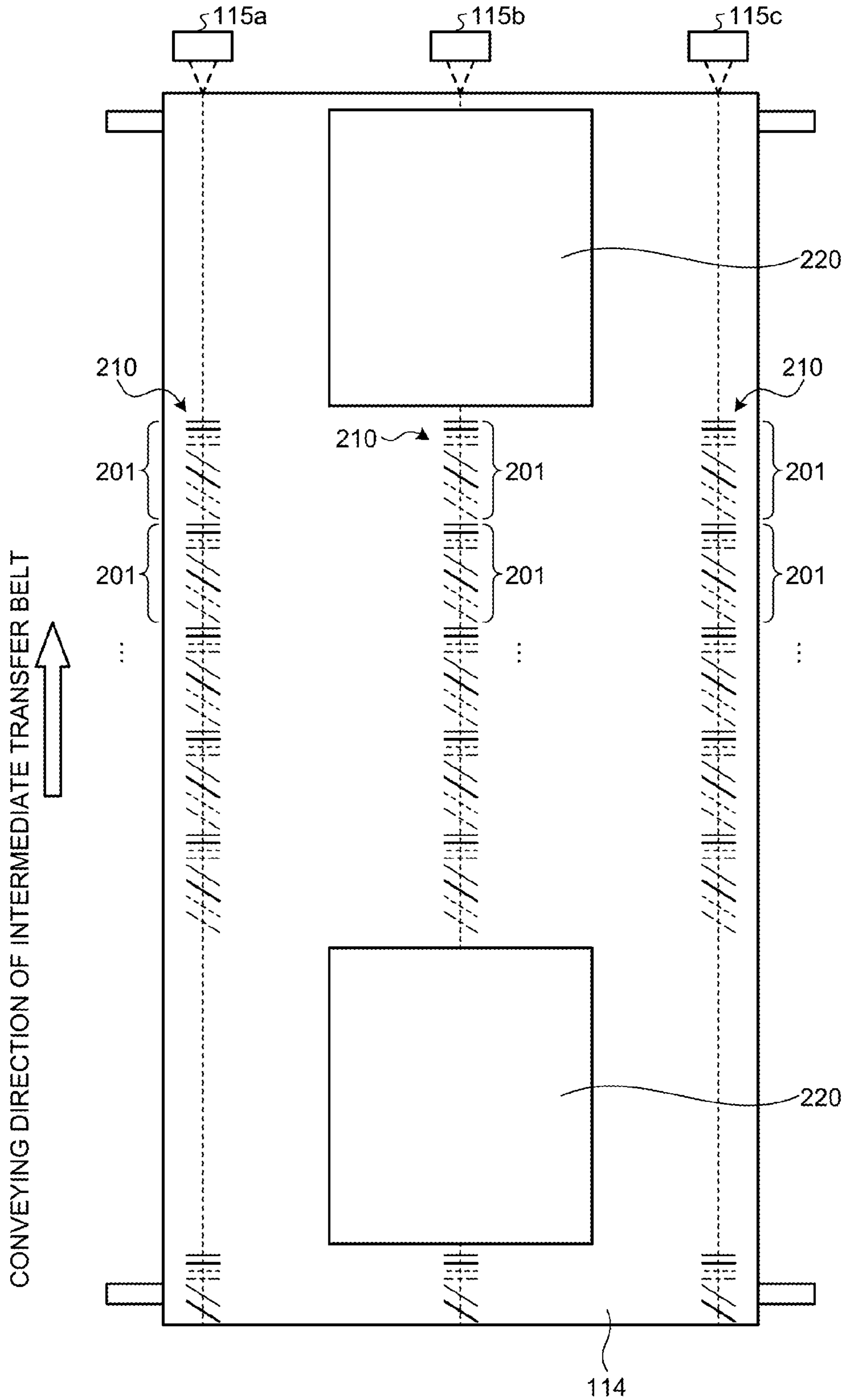

115a
115b
115c
220
210
210
210
201
201
201
201
201
201
CONVEYING DIRECTION OF INTERMEDIATE TRANSFER BELT
220
114

FIG.11

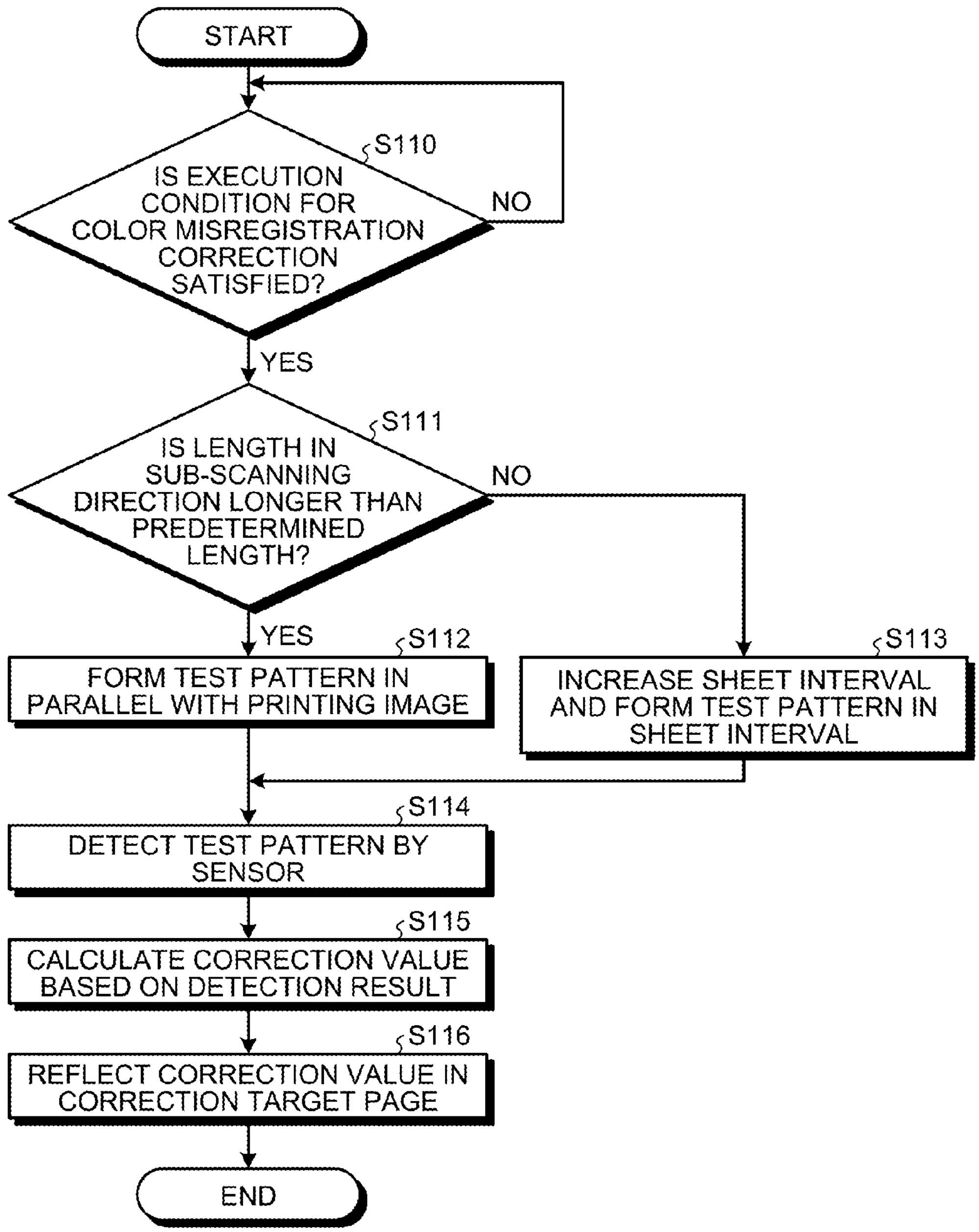

START
S110
IS EXECUTION CONDITION FOR COLOR MISREGISTRATION CORRECTION SATISFIED?
NO
YES
S111
IS LENGTH IN SUB-SCANNING DIRECTION LONGER THAN PREDETERMINED LENGTH?
NO
YES
S112
FORM TEST PATTERN IN PARALLEL WITH PRINTING IMAGE
S113
INCREASE SHEET INTERVAL AND FORM TEST PATTERN IN SHEET INTERVAL
S114
DETECT TEST PATTERN BY SENSOR
S115
CALCULATE CORRECTION VALUE BASED ON DETECTION RESULT
S116
REFLECT CORRECTION VALUE IN CORRECTION TARGET PAGE
END

IMAGE FORMING APPARATUS AND IMAGE FORMING APPARATUS CONTROL METHOD

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application claims priority to and incorporates by reference the entire contents of Japanese Patent Application No. 2012-200977 filed in Japan on Sep. 12, 2012.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an image forming apparatus that forms an image with toners of multiple colors and to an image forming apparatus control method.

2. Description of the Related Art

Conventionally, there is a known image forming apparatus that forms electrostatic latent images on photoreceptors through optical writing, temporarily transfers toner images developed from the electrostatic latent images onto an intermediate transfer member, such as an intermediate transfer belt, for each of colors such that the toner images of the respective colors are superimposed on the intermediate transfer member, transfers the toner images of the respective colors from the intermediate transfer member to a sheet of paper, and fixes the toner images to the sheet of paper to thereby form a color image.

In such an image forming apparatus, image adjustment, such as color misregistration correction or density correction, on an image to be formed is generally performed by forming a test pattern on the intermediate transfer belt and detecting the test pattern by a sensor. However, normal image formation on the sheet of paper cannot be performed while the above-described image adjustment is being performed. Therefore, if the image adjustment is frequently performed, downtime increases, during which the image formation on the sheet of paper is interrupted. Consequently, it becomes difficult to efficiently form images.

Japanese Patent Application Laid-open No. 2006-293240 discloses a technology in which, in an image forming apparatus where the maximum image width available for image formation in the main-scanning direction is smaller than a sum of the maximum width of an available recording material in the main-scanning direction and the lengths of pattern images formed at two portions for density correction or misregistration correction in the width direction of the recording material, an area where the pattern images are to be formed is changed depending on whether the width of a recording material to be actually used is equal to or smaller than a threshold or whether the width of the recording material is greater than the threshold. More specifically, if the width of a recording material to be used is equal to or smaller than the threshold, the pattern images are formed in an image area through which a sheet of paper does not pass, and, if the width of the recording material is greater than the threshold, the pattern images are formed in an inter-sheet area between the trailing end of a preceding recording material and the leading end of a following recording material. According to Japanese Patent Application Laid-open No. 2006-293240, it is possible to prevent an increase in the size of the image forming apparatus in the sheet width direction due to formation of the pattern images for density correction or misregistration correction in an area outside the maximum sheet width, and it is also possible to prevent a decrease in the throughput due to formation of the pattern images in the inter-sheet area.

Meanwhile, in the conventional image adjustment method in which a test pattern is formed in an area outside a printing area in parallel with printing of the image, an execution condition is set such that the size of a printing image in the main-scanning direction is smaller than a predetermined size in order to prevent overlapping of the printing image and the test pattern, but the size of the printing image in the sub-scanning direction is not set in the execution condition.

An example will be described below, in which images are sequentially formed on a page-by-page basis. In this case, an image formation condition for a next page following a current page is set after completion of the image formation of the current page is detected. When a test pattern is formed in parallel with the printing image, settings for the test pattern are set at the same time settings for the next page are set.

When the test pattern is formed in parallel with the printing image without taking into account the image size in the sub-scanning direction, a timing at which formation of the printing image is completed and a timing at which formation of the test pattern is completed cannot be distinguished. Therefore, in the conventional operation for setting image settings for a next page after detecting the completion of the image formation of a current page, the image settings may be set even before formation of the test pattern is not completed. In this case, there is a problem in that a formation condition for the test image may be changed while the test pattern is being formed.

In the technology disclosed in Japanese Patent Application Laid-open No. 2006-293240, because only a sheet size in the main-scanning direction is set as a determination condition, if the test pattern is formed without taking into account the image size in the sub-scanning direction, a timing of completion of the formation of the test pattern cannot be distinguished. Therefore, even with the technology of Japanese Patent Application Laid-open No. 2006-293240, it is difficult to set the image settings for a next page at an appropriate timing, so that it is difficult to solve the problem in that the formation condition for the test image may be changed while the test pattern is being formed.

Therefore, there is a need for an image forming apparatus capable of executing image settings at an appropriate timing when a test pattern is formed in an area outside a printing area in parallel with printing of the image.

SUMMARY OF THE INVENTION

According to an embodiment, there is provided an image forming apparatus that includes a first image forming unit that forms toner images based on image data on a plurality of first image carriers; a second image carrier, which moves at a predetermined speed and on which the toner images formed on the first image carriers by the image forming unit are transferred; a second image forming unit that transfers the toner images transferred on the second image carrier onto a transfer medium that is moved at the predetermined speed; a test pattern generating unit that generates a test pattern group with a predetermine length in a moving direction of the second image carrier; and an adjusting unit that determines a method to adjust an image formation condition for the first image forming unit using the test pattern group, based on a relationship between the predetermined length and a length of an image area, in which a print image based on the image data is formed, in a sub-scanning direction corresponding to the moving direction of the second image carrier.

The above and other objects, features, advantages and technical and industrial significance of this invention will be better understood by reading the following detailed description of presently preferred embodiments of the invention, when considered in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a diagram illustrating a configuration example of an image forming apparatus applicable to an embodiment of the present invention;

FIG. **2** is a diagram illustrating a configuration example of a sensor applicable to the embodiment;

FIG. **3** is a block diagram illustrating a configuration example of a signal processing system applicable to the embodiment;

FIG. **4** is a diagram illustrating examples of test pattern rows according to the embodiment and an output signal output by the sensor when the sensor detects the test pattern rows.

FIG. **5** is a diagram for explaining color misregistration detection by using test pattern images applicable to the embodiment;

FIG. **6** is a diagram for explaining how a process for forming the test pattern rows according to the embodiment is performed in parallel with a process for transferring printing images on an intermediate transfer belt;

FIG. **7** is a diagram for explaining an example in which the length of a printing image is shorter than the length of a test pattern group;

FIG. **8** is a diagram for explaining an example in which the length of a printing image is equal to or longer than the length of a test pattern group;

FIG. **9** is a flowchart illustrating an example of a process for adjusting an image formation condition according to the embodiment;

FIG. **10** is a diagram for explaining a method for forming a test pattern group according to a modification of the embodiment; and

FIG. **11** is a flowchart illustrating an example of a process for adjusting an image formation condition according to the modification of the embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Exemplary embodiments of the present invention will be explained in detail below with reference to the accompanying drawings. FIG. **1** illustrates a configuration example of an image forming apparatus **100** applicable to an embodiment of the present invention.

Configuration Applicable to the Embodiment

The image forming apparatus **100** includes an optical device **102** including optical elements, such as a semiconductor laser and a polygon mirror; an image forming unit **112** including photosensitive drums, charging units, developing units, and the like; and a transfer unit **122** including an intermediate transfer belt and the like. The optical device **102**, the image forming unit **112**, and the transfer unit **122** implement functions of image forming means. A temperature sensor **150** is disposed inside a casing of the image forming apparatus **100**.

The optical device **102** deflects light beams emitted by a laser light source, such as a semiconductor laser (not illustrated), by using a polygon mirror **102***c* to cause the light beams to enter fθ lenses **102***b*. In the example illustrated in FIG. **1**, the same number of light beams as the number of colors of yellow (Y), magenta (M), cyan (C), and black (K) are emitted. The light beams of the respective colors pass through the fθ lenses **102***b*, are reflected by reflecting mirrors **102***a*, and are incident on WTL lenses **102***d*.

The WTL lenses **102***d* shape the light beams and deflect the light beams toward reflecting mirrors **102***e* so that the light beams based on images are applied as light beams L used for exposure to photosensitive drums **104***a*, **106***a*, **108***a*, and **110***a*. The light beams L are applied to the photosensitive drums **104***a*, **106***a*, **108***a*, and **110***a* via a plurality of the optical elements as described above. Therefore, a timing in the main-scanning direction that is a scanning direction of the light beams L and a timing in the sub-scanning direction orthogonal to the main-scanning direction are synchronized. Incidentally, the sub-scanning direction is generally defined as a rotation direction of the photosensitive drums **104***a*, **106***a*, **108***a*, and **110***a*.

Each of the photosensitive drums **104***a*, **106***a*, **108***a*, and **110***a* is structured such that a photoconductive layer including at least a charge generation layer and a charge transport layer is formed on a conductive drum made of aluminum or the like. The photoconductive layer is arranged in accordance with each of the photosensitive drums **104***a*, **106***a*, **108***a*, and **110***a*, and each of charging units **104***b*, **106***b*, **108***b*, and **110***b* including a corotron, a scorotron, or a charging roller, applies surface charges to the photoconductive layer.

The photosensitive drums **104***a*, **106***a*, **108***a*, and **110***a* on which static charges are applied by the charging units **104***b*, **106***b*, **108***b*, and **110***b*, respectively, are exposed with the light beams L based on images, so that electrostatic latent images are formed. The electrostatic latent images formed on the photosensitive drums **104***a*, **106***a*, **108***a*, and **110***a* are respectively developed by developing units **104***c*, **106***c*, **108***c*, and **110***c* each including a developing sleeve, a developer supply roller, a regulation blade, and the like, so that developer images are formed.

The developers carried on the photosensitive drums **104***a*, **106***a*, **108***a*, and **110***a* are transferred onto an intermediate transfer belt **114** that is moved in a direction of an arrow B by conveying rollers **114***a*, **114***b*, and **114***c*. The intermediate transfer belt **114** is moved toward a secondary transfer unit while carrying the developers of the colors of C, M, Y, and K. The secondary transfer unit includes a secondary transfer belt **118** and conveying rollers **118***a* and **118***b*. The secondary transfer belt **118** is moved in a direction of an arrow C by the conveying rollers **118***a* and **118***b*. An image receiving medium **124**, such as a high-quality sheet or a plastic sheet, is fed from an image receiving medium housing unit **128**, such as a sheet cassette, to the secondary transfer unit by a conveying roller **126**.

The secondary transfer unit applies a secondary transfer bias to transfer a multicolor developer image carried on the intermediate transfer belt **114** onto the image receiving medium **124** that is adsorbed and held on the secondary transfer belt **118**. The image receiving medium **124** is fed to a fixing device **120** along with movement of the secondary transfer belt **118**. The fixing device **120** includes a fixing member **130**, such as a fixing roller, containing a silicone rubber or a fluoro-rubber, applies heat and pressure to the image receiving medium **124** carrying the multicolor developer image to form a printed matter **132**, and outputs the printed matter **132** to the outside of the image forming apparatus **100**. After the multicolor developer image is transferred, residual developer remaining on the intermediate transfer belt **114** is removed by a cleaning unit **116** including a cleaning blade, and the intermediate transfer belt **114** is made ready for a next image formation process.

The image forming apparatus **100** according to the embodiment forms a color misregistration correction test pattern on the intermediate transfer belt **114** to adjust the quality of an image to be formed. On the downstream side of the photosensitive drums **104***a*, **106***a*, **108***a*, and **110***a* in the moving direction of the intermediate transfer belt **114**, sensors **115***a*, **115***b*, and **115***c* are disposed to detect the color misregistration correction test pattern formed on the intermediate transfer belt **114**. The sensors **115***a*, **115***b*, and **115***c* are arranged as close as possible to the photosensitive drum **104***a* on the most downstream side in the moving direction of the intermediate transfer belt **114** so that the color misregistration correction test pattern can be detected at an earlier timing.

FIG. **2** illustrates a configuration example of the sensors **115***a*, **115***b*, and **115***c* applicable to the embodiment. The same configuration can be applied to the sensors **115***a*, **115***b*, and **115***c*; therefore, in the following, the sensors **115***a*, **115***b*, and **115***c* are referred to as a sensor **115** as long as they need not be distinguished.

In FIG. **2**, the sensor **115** includes one light-emitting element **602** and two light-receiving elements **603** and **604**. The light-emitting element **602** is, for example, an infrared light emitting diode (LED), and irradiates the intermediate transfer belt **114** with the emitted infrared light. A laser light-emitting element may be used as the light-emitting element **602**. Each of the light-receiving elements **603** and **604** is, for example, a phototransistor. A photodiode may be employed as each of the light-receiving elements **603** and **604** to amplify the output.

In this example, the light-receiving element **603** is arranged at a position so as to receive specular reflected light, which is infrared light emitted from the light-emitting element **602** and specularly reflected from the intermediate transfer belt **114**, and the light-receiving element **604** is arranged at a position so as not to receive the specular reflected light. Specifically, the light-receiving element **604** receives diffuse reflected light, which is infrared light emitted by the light-emitting element **602** and diffusely reflected from the intermediate transfer belt **114**. A focusing lens **605** is disposed on the optical path of the infrared light emitted from the light-emitting element **602** and on the optical paths of the specular reflected light and the diffuse reflected light that are infrared light reflected from the intermediate transfer belt **114**.

In FIG. **2**, the light-receiving element **603** for receiving the specular reflected light and the light-receiving element **604** for receiving the diffuse reflected light are provided. However, the present invention is not limited to this example. It may be possible to provide only one of the light-receiving elements depending on a detecting object or necessary information.

FIG. **3** illustrates a configuration example of a signal processing system in the image forming apparatus **100** applicable to the embodiment. In the following, components for detecting the amount of color misregistration which are deeply related to the embodiment among all of the components of the image forming apparatus **100** are mainly described.

A central processing unit (CPU) **10** performs predetermined arithmetic processing and controls a pattern detection of the embodiment, according to a program stored in a read only memory (ROM) **12** in advance, by using a random access memory (RAM) **11** as a working memory. The CPU **10** is connected to an input/output (I/O) port **13** via a data bus. The I/O port **13** controls read of data from first-in first-out (FIFO) memory units **18***a*, **18***b*, and **18***c* (to be described later) or data transfer via the data bus. A detection result of a temperature inside the casing detected by the temperature sensor **150** is supplied to the CPU **10**.

The program stored in the ROM **12** includes modules for executing various processes including a test pattern row correction process. Examples of the modules include a module for executing a correction process for correcting an image formation condition for forming a color mage on the intermediate transfer belt **114**, and a module for a calculation process for calculating the amount of positional misregistration in the main-scanning direction when a test pattern row is formed on the intermediate transfer belt **114**.

The ROM **12** also pre-stores therein setting values for setting various operation conditions for each of the units of the image forming apparatus **100**, a correction value of each of the setting values based on the internal temperature of the image forming apparatus **100**, and the like. For example, various setting values of an electrical current for driving the laser light source, a rotation speed of the polygon mirror **102***c*, a rotation speed of each of the photosensitive drums **104***a*, **106***a*, **108***a*, and **110***a*, or a driving speed of the intermediate transfer belt **114**, and a correction value of each of the setting values based on the internal temperature of the image forming apparatus **100** are stored in the ROM **12** in advance.

Signal processing units **30***a*, **30***b*, and **30***c* perform signal processing on the sensors **115***a*, **115***b*, and **115***c*, respectively. Specifically, the signal processing unit **30***a* includes a light-emission intensity control unit **14***a*, an amplifying unit **15***a*, a filter unit **16***a*, an analog-to-digital (A/D) converting unit **17***a*, the FIFO memory unit **18***a*, and a sampling control unit **19***a*. An output from the light-emission intensity control unit **14***a* is supplied to a light-emitting element **602***a* of the sensor **115***a*, and outputs from light-receiving elements **603***a* and **604***a* of the sensor **115***a* are supplied to the amplifying unit **15***a*.

Similarly, the signal processing unit **30***b* includes a light-emission intensity control unit **14***b*, an amplifying unit **15***b*, a filter unit **16***b*, an A/D converting unit **17***b*, the FIFO memory unit **18***b*, and a sampling control unit **19***b*. An output from the light-emission intensity control unit **14***b* is supplied to a light-emitting element **602***b* of the sensor **115***b*, and outputs from light-receiving elements **603***b* and **604***b* the sensor **115***b* are supplied to the amplifying unit **15***b*. Furthermore, the signal processing unit **30***c* includes a light-emission intensity control unit **14***c*, an amplifying unit **15***c*, a filter unit **16***c*, an A/D converting unit **17***c*, the FIFO memory unit **18***c*, and a sampling control unit **19***c*. An output from the light-emission intensity control unit **14***c* is supplied to a light-emitting element **602***c* of the sensor **115***c*, and outputs from light-receiving elements **603***c* and **604***c* of the sensor **115***c* are supplied to the amplifying unit **15***c*.

As described above, the signal processing units **30***a*, **30***b*, and **30***c* have the same configuration. Therefore, in the following, the signal processing unit **30***a* will be explained as a representative example of the signal processing units **30***a*, **30***b*, and **30***c*.

In the sensor **115***a*, a light-receiving element **603***a* that receives specular reflected light among the two light-receiving elements **603***a* and **604***a* is used to detect a test pattern formed on the intermediate transfer belt **114** (to be described later).

In the sensor **115***a*, when the light-receiving element **603***a* receives reflected light of the infrared light emitted by the light-emitting element **602***a*, the light-receiving element **603***a* outputs an analog detected signal corresponding to the intensity of the received infrared light. The analog detected signal is amplified by the amplifying unit **15***a*. A signal component for line detection is selectively passed through the filter unit **16***a* and supplied to the A/D converting unit **17***a* where the signal is converted to digital detected data. The sampling control unit **19***a* controls sampling of the detected data converted by the A/D converting unit **17***a*. The detected data sampled by the A/D converting unit **17***a* is stored in the FIFO memory unit **18***a*.

When detection of one test pattern is completed, the sampling control unit **19***a* causes the detected data of the test pattern stored in the FIFO memory unit **18***a* to be output from the FIFO memory unit **18***a*. The detected data output from the FIFO memory unit **18***a* is supplied to the CPU **10** and the RAM **11** via the I/O port **13**. The CPU **10** calculates amounts of various types of misregistration, such as the amount of color misregistration, according to a program stored in the ROM **12**.

The CPU **10** calculates a color misregistration correction value for correcting the amount of color misregistration calculated based on a detection result of the test pattern. The CPU **10** sets a change in the write start timing or the pixel clock frequency in the write control unit **21** in order to perform correction based on the calculated color misregistration correction value.

The write control unit **21** has a mechanism, such as a clock generator using a voltage controlled oscillator (VCO), capable of setting the output frequency in detail, and uses the output as a pixel clock. The write control unit **21** controls an LD lighting control unit **22** according to the image data transferred by a controller **20** with reference to the pixel clock, and the LD lighting control unit **22** controls lighting of a laser light source (not illustrated) under the control of the write control unit, so that images are written on the photosensitive drums **104***a*, **106***a*, **108***a*, and **110***a*. The controller **20** includes a CPU and controls the entire operation of the image forming apparatus **100**.

A write control unit **21** writes the images on the photosensitive drums **104***a*, **106***a*, **108***a*, and **110***a* at a write timing or a pixel clock frequency that is set by the CPU **10** based on the color misregistration correction value, so that the images corrected based on the color misregistration correction value can be formed.

Meanwhile, the CPU **10** monitors the analog detected signal from the light-receiving element **603***a* at an appropriate timing, generates a control signal for controlling the level of the infrared light emitted by the light-emitting element **602***a* based on the monitoring result, and supplies the control signal to the light-emission intensity control unit **14***a* via the I/O port **13**. The light-emission intensity control unit **14***a* controls the amount of light emitted by the light-emitting element **602***a* according to the control signal. Therefore, the level of the infrared light emitted by the light-emitting element **602***a* can be set to an approximately constant level, so that it becomes possible to reliably detect the test pattern even when the intermediate transfer belt **114** or the laser light source (not illustrated) is deteriorated.

FIG. **4** illustrates test pattern rows and an output signal of the sensor when the sensor detects the test pattern rows. As illustrated in section (b) in FIG. **4**, three test pattern rows **210** are arranged such that a plurality of test pattern images **201**, **201**, . . . are arranged in accordance with the positions of sensors **115***a*, **115***b*, and **115***c* along the sub-scanning direction. In this case, eight test pattern images **201** are arranged as one set along the sub-scanning direction. Each of the test pattern images **201** contains patterns (horizontal patterns) that are formed horizontally with respect to the main-scanning direction of the photosensitive drums **104***a*, **106***a*, **108***a*, and **110***a* in order of the colors Y, K, M, and C, and patterns (diagonal patterns) that are formed at an angle of 45° with respect to the main-scanning direction in order of the colors Y, K, M, and C. The order of the colors of the horizontal patterns and the diagonal patterns may be changed.

When the intermediate transfer belt **114** on which the test pattern rows **210** are formed as described above is conveyed in the sub-scanning direction, the sensors **115***a*, **115***b*, and **115***c* move on the test pattern rows **210** along trajectories **202***a*, **202***b*, and **202***c* illustrated in section (b) in FIG. **4**.

Section (a) in FIG. **4** illustrates an example of an output signal of the sensor **115***a* when the sensor **115***a* moves along the trajectory **202***a* for example. The sensor **115***a* detects the intermediate transfer belt **114** at portions other than the horizontal patterns and the diagonal patterns. For example, if the intermediate transfer belt **114** is colored in white and a detection level of white is set as a reference level, the detection level at the horizontal patterns and the diagonal patterns colored in other colors is reduced to a low (Low) state. The determination of the low state is performed based on, for example, whether the detection level is equal to or smaller than a predetermined threshold voltage level V_{th}. The CPU **10** detects each of the patterns by detecting the low state of the output from the sensor **115***a*.

The color misregistration detection by using the test pattern images **201** will be explained below with reference to FIG. **5**. To calculate color misregistration in the sub-scanning direction, a horizontal pattern **203** is used and intervals (y_1, m_1, c_1) between the pattern of the color K serving as a reference color and the patterns of the other colors Y, M, and C are measured. Each of the measurement results is compared with an ideal distance between the corresponding color and the reference color to calculate the color misregistration in the sub-scanning direction.

To calculate the color misregistration in the main-scanning direction, intervals (y_2, k_2, m_2, c_2) between the lines of the horizontal pattern **203** and corresponding lines of a diagonal pattern **204** are measured. Each of the lines of the diagonal pattern **204** is inclined by an angle of 45° with respect to the main-scanning direction. Therefore, a difference in the measured interval between the reference color (the color K) and each of the other colors Y, M, and C serves as the amount of color misregistration of each of the colors Y, M, and C in the main-scanning direction. For example, the amount of color misregistration of the color Y in the main-scanning direction is obtained by k_2-y_2. As described above, it is possible to obtain the amounts of color misregistration (registration deviation) in the sub-scanning direction and in the main-scanning direction by using the test pattern images **201**.

The detection of the amount of color misregistration as described above can be performed by using, for example, at least one of the test pattern images **201**. If a plurality of the test pattern images **201** are used to detect the amount of color misregistration for each of the colors, it becomes possible to more accurately perform the color misregistration correction. For example, it may be possible to calculate the amount of color misregistration for each of the colors by performing a statistical processing, such as an averaging, on the amounts of color misregistration calculated by using the plurality of the test pattern images **201**.

Furthermore, if the detection of the amount of color misregistration is performed by using the sensors **115***a*, **115***b*, and **115***c* disposed at different positions in the main-scanning direction, it becomes possible to detect components in the main-scanning direction and in the sub-scanning direction for each of the misregistration amount. For example, it is possible to obtain a skew component by calculating a difference between the amounts of color misregistration in the sub-scanning direction detected by the sensors **115***a* and **115***c*. Furthermore, if a pattern corresponding to the sensor **115***b* is additionally formed and differences in the amounts of color misregistration in the main-scanning direction between the sensors **115***a* and **115***b* and between the sensors **115***b* and **115***c* are calculated, it is possible to obtain a deviation in the magnification error.

As described above, by combining detection results of a plurality of the test pattern rows **210** output by the sensors **115***a*, **115***b*, and **115***c*, it is possible to adjust an image formation condition by correcting a plurality of items, such as misregistration in main-scanning direction, misregistration in the sub-scanning direction, skew correction, and a deviation in the magnification error in the main-scanning direction.

The test pattern used for adjusting the image quality at the time of printing includes various patterns other than the test pattern images **201** for the color misregistration correction. In this case, by forming only the test pattern images **201** for the color misregistration correction when the color misregistration correction is to be performed, it becomes possible to save toner consumed for forming test patterns for other image adjustment.

Next, a process for forming the test pattern rows **210** and transferring a printing image on the intermediate transfer belt **114** in a parallel way will be explained below with reference to FIG. **6**. When formation of the test pattern rows **210** and transfer of a printing image **220** onto the intermediate transfer belt **114** are performed in a parallel way, the sensors **115***a* and **115***c* arranged at both ends in the main-scanning direction among the sensors **115***a*, **115***b*, and **115***c* are disposed at positions corresponding to the outer end portions of an image area of the printing image **220**. As for the test pattern rows **210**, the two test pattern rows **210** at both edges in the main-scanning direction are formed and the test pattern row **210** corresponding to the sensor **115***b* located in the center in the main-scanning direction is not formed among the test pattern rows **210**.

Furthermore, in the example in FIG. **6**, the test pattern row **210** is formed such that multiple sets of the test pattern images **201** are sequentially arranged, where each set includes eight test pattern images **201**.

As described above, by transferring the printing image **220** and forming the test pattern rows **210** onto the intermediate transfer belt **114** in a parallel way, and by adjusting the image quality of the printing image **220** based on the detection results of the test pattern rows **210**, it becomes possible to reduce occurrence of a suspension period of printing operation due to the image quality adjustment, that is, to reduce so-called downtime. Consequently, it becomes possible to improve the productivity of the image forming apparatus **100**.

Meanwhile, as illustrated in FIG. **6**, in a system in which the output from the sensor **115***b* located in the center in the main-scanning direction is not used, it is possible to correct misregistration in the main-scanning direction, correct misregistration in the sub-scanning direction, and perform skew correction, but it is impossible to correct a deviation in the magnification error in the main-scanning direction.

Process According to the Embodiment

Adjustment of the image formation condition according to the embodiment will be explained below. As explained above with reference to FIG. **6**, the image forming apparatus **100** according to the embodiment forms the test pattern rows **210** and transfer the printing image **220** onto the intermediate transfer belt **114** in a parallel way. In this case, for example, the image forming apparatus **100** adjusts the image formation condition by using the consecutive eight test pattern images **201** serving as one unit in the test pattern row **210**. Specifically, the image forming apparatus **100** performs a statistical processing, such as an averaging, on the detection results of

the eight consecutive test pattern images **201** to obtain the amount of color misregistration for each of the colors, and calculates the correction values of a plurality of items needed to adjust the image formation condition.

Hereinafter, the eight consecutive test pattern images **201** serving as one unit for adjusting the image formation condition are collectively referred to as a test pattern group.

When formation of the test pattern rows **210** and transfer of the printing image **220** onto the intermediate transfer belt **114** are performed in a parallel way, and if the image formation condition is adjusted in units of a test pattern group formed of a predetermined number of the test pattern images **201**, a process to be performed differs depending on a relationship between the length of an image area in which the printing image **220** is to be formed in the sub-scanning direction and the length of the test pattern group. Specifically, in the embodiment, the direction of adjusting the image formation condition is determined depending on the relationship between the length of the image area in the sub-scanning direction and the length of the test pattern group.

Meanwhile, it is assumed that the image formation condition for a certain page in the image area are set by using completion of the image area of a previous page preceding the certain page as a trigger. The setting of the image formation condition at this time include setting of formation conditions for forming the test pattern images **201**. The image area may be formed such that the length of the image area in the sub-scanning direction is equal to the length of the printing image **220** in the sub-scanning direction and the printing image **220** is formed in the image area, or may be formed so as to correspond to the length of a transfer medium (printing sheet) in the sub-scanning direction on which the printing image **220** is to be transferred. The image area is indicated by, for example, the image area signal generated by the controller **20**.

Specifically, if the image area is formed as an area in which the printing image **220** is to be formed, the formation completion timing of the printing image **220** is a timing at which the image area signal is negated. For example, if the image area signal is in the low (L: Low) state indicating a period during which the printing image **220** of one page is transferred, a timing at which the image area signal in the L state is negated and enters the high (H: High) state indicates a timing at which the formation of the printing image **220** of one page is completed. Therefore, by sampling the image area signal of each of the colors, it is possible to recognize a timing at which the printing image **220** of each of the colors is completed. Therefore, it becomes possible to set an image condition for a next page at an appropriate timing.

However, if a magnitude relation between the length of the image area in the sub-scanning direction and the length of the test pattern group is not clear, it may be possible that formation of the test pattern group is not completed at a time t_{K2} corresponding to the trailing end of the image area.

With reference to FIG. **7**, an example will be explained in which the length of the image area is shorter than the length of the test pattern group. In the example in FIG. **7**, as for the color K for example, an image area signal (K) enters the L state at a time t_{K1}, and formation of the printing image **220** is started. Thereafter, the image area signal (K) is negated and enters the H state at the time t_{K2}, indicating that the formation of the printing image **220** of one page is completed. After a lapse of a predetermined time designated as an interval between image areas, the image area signal (K) is asserted at a time t_{K5}, so that formation of the printing image **220** of a next page is started. The predetermined time is set to a longer time than a time needed to set the image condition.

In the example in FIG. **7**, the length of the test pattern group is longer than the length of the image area in the sub-scanning direction. Therefore, the image area signal (K) is asserted at the time t_{K1} so that formation of the printing image **220** and formation of the test pattern group are started simultaneously. At a time t_{K3} later than the time t_{K2} at which the image area signal (K) is negated and formation of the printing image **220** is completed, formation of the test pattern group is completed.

As described above, the setting of the image formation condition is started at the time t_{K2} at which the image area signal (K) is negated, and finished at the time t_{K4} after a lapse of a predetermined time. At the time t_{K2} at which the setting of the image formation condition is started, formation of the test pattern group is not yet completed. Therefore, the image formation condition for the test pattern group may be changed to the image formation condition for a next page even when the test pattern group is being formed.

If the setting of the image formation condition for the test pattern group is not performed appropriately, the shape of the test pattern group may be changed in the middle of the test pattern group, and it may become difficult to accurately perform various types of color misregistration detection. Consequently, the image quality of the printing image **220** to be formed may be reduced.

With reference to FIG. **8**, an example will be explained in which the length of the image area is equal to or longer than the length of the test pattern group. In this case, the image area signal (K) is asserted at a time t_{K10}, and formation of the test pattern group that is started at the same time as the start of formation of the printing image **220** is surely completed before a time tK_{12}, at which the image area signal (K) is negated and formation of the printing image **220** is completed (see a time t_{K11}).

Therefore, the setting of the image formation condition that occurs based on the detection result of the test pattern group by using negation of the image area signal (K) as a trigger is started after completion of all of the test pattern group is detected. Therefore, it is possible to prevent a situation as explained above with reference to FIG. **7**, in which the image formation condition for the test pattern group is changed to an image formation condition of a next page even when the test pattern group is being formed.

The setting of the image formation condition started at the time t_{K12} is finished at a time t_{K13}. When a predetermined time designated as an interval between the printing images **220** has elapsed since the time t_{K12}, and if a time t_{K14} comes after the time t_{K13} at which the setting of the image formation condition is completed, formation of the printing image **220** of a next page and formation of the test pattern group are started according to the image formation condition set in the period from the time t_{K12} to the time t_{K13}.

FIG. **9** is a flowchart illustrating an example of a process for adjusting the image formation condition according to the embodiment. Each process in the flowchart in FIG. **9** is executed by causing the CPU **10** to read a program from the ROM **12** and control each of the units of the image forming apparatus **100**. In the following, it is assumed that an image area serves as an image formation area for the printing image **220**, and an image area signal indicates a period corresponding to the area in the sub-scanning direction.

Before execution of the process in the flowchart in FIG. **9**, the CPU **10** monitors the status of each of the units of the image forming apparatus **100**. At Step **S100**, the CPU **10** determines whether the status of the image forming apparatus **100** satisfies an execution condition for executing the color misregistration correction, based on the monitoring result. Examples of the execution condition include a temperature of the image forming apparatus **100** and the total number of printed sheets. When determining that the status of the image forming apparatus **100** does not satisfy the execution condition, the CPU **10** repeats the process at Step **S100**.

When determining that the status of the image forming apparatus **100** satisfies the execution condition for executing the color misregistration correction, the CPU **10** causes the process to proceed to Step **S101**. At Step **S101**, the CPU **10** determines whether the image area (for example, the printing image **220**) designated by a current print job is longer than a predetermined length in the sub-scanning direction. The predetermined length is, for example, the length of the test pattern group.

When determining that the length in the sub-scanning direction is equal to or shorter than the predetermined length, the CPU **10** does not form the test pattern group on the intermediate transfer belt **114** and does not perform the color misregistration correction process. Therefore, it is possible to prevent a situation as illustrated in FIG. **7**, in which the image formation condition for the test pattern group is changed to an image formation condition of a next page even when the test pattern group is being formed.

At Step **S101**, when determining that the length of the printing image **220** in the sub-scanning direction is longer than the predetermined length, the CPU **10** causes the process to proceed to Step **S102**, and starts formation of the test pattern groups corresponding to the sensors **115***a* and **115***c* on the intermediate transfer belt **114** in parallel with formation of the printing image **220**.

The CPU **10** detects the test pattern groups based on the outputs from the sensors **115***a* and **115***c* (Step **S103**). At Step **S104**, as explained above with reference to FIG. **5**, the amounts of color misregistration in the main-scanning direction and in the sub-scanning direction are obtained based on information on the detected test pattern groups, and various correction values are calculated based on the obtained amounts of color misregistration. After calculating the correction values, at Step **S105**, the CPU **10** reflects the correction values calculated at Step **S104** in the formation of the printing image **220** of a correction target page.

As described above, according to the embodiment, when it is determined that the length of the image area in the sub-scanning direction is equal to or shorter than a predetermined length, the test pattern group is not formed on the intermediate transfer belt **114** and the color misregistration correction process is not performed. Therefore, it is possible to prevent a situation in which the image formation condition is changed to an image formation condition for a next page while the test pattern group is being formed. In this regard, however, because the color misregistration correction process is not performed when the length of the image area in the sub-scanning direction is equal to or shorter than the predetermined length, the image quality may be reduced.

In the embodiment, the image area is set as an image area in which the printing image **220** is formed. However, the present invention is not limited to this example. For example, the image area may be set as an area of a transfer medium on which the printing image **220** is transferred.

In this case, when the length of the transfer medium in the sub-scanning direction is longer than the length of the test pattern group, the process proceeds to Step **S102**. Furthermore, when the length of the transfer medium in the sub-scanning direction is equal to or shorter than the length of the test pattern group, the test pattern group is not formed and the color misregistration correction process is not performed. In this case, the test pattern group is formed on the outside of the transfer medium in the sub-scanning direction.

Modification of the Embodiment

A modification of the embodiment will be explained below. In the modification of the embodiment, as illustrated in FIG. **10** for example, when the length of the image area in the sub-scanning direction is equal to or shorter than a predetermined length, a sheet interval is increased and the test pattern groups corresponding to the sensors **115***a*, **115***b*, and **115***c* are formed in an area of the increased sheet interval on the intermediate transfer belt **114**. The sheet interval is an interval in the sub-scanning direction between a transfer medium on which the printing image **220** of a certain page is transferred and a transfer medium on which the printing image **220** of a next page is transferred. The CPU **10** performs the color misregistration correction process based on the detection results obtained by the sensors **115***a*, **115***b*, and **115***c* by detecting the test pattern groups formed in the area of the increased sheet interval on the intermediate transfer belt **114**, and sets an image formation condition for a next page.

FIG. **11** illustrates an example of a process for adjusting the image formation condition according to the modification of the embodiment. Each process in the flowchart in FIG. **11** is executed by causing the CPU **10** to read a program from the ROM **12** and control each of the units of the image forming apparatus **100**.

Before execution of the process in the flowchart in FIG. **11**, the CPU **10** monitors the status of each of the units of the image forming apparatus **100**, and determines whether the status of the image forming apparatus **100** satisfies an execution condition for executing the color misregistration correction based on the monitoring result (Step S**110**). When determining that the status of the image forming apparatus **100** does not satisfy the execution condition, the CPU **10** repeats the process at Step S**110**.

When determining that the status of the image forming apparatus **100** satisfies the execution condition for executing the color misregistration correction, the CPU **10** causes the process to proceed to Step S**111**. At Step S**111**, the CPU **10** determines whether the length of the image area (for example, the printing image **220**) designated by a current print job is longer than a predetermined length (for example, the length of the test pattern group) in the sub-scanning direction.

When determining that the length of the image area in the sub-scanning direction is equal to or shorter than the predetermined length, the CPU **10** causes the process to proceed to Step S**113**. At Step S**113**, the CPU **10** increase the sheet interval to the predetermined length or longer. For example, the CPU **10** instructs the controller **20** to increase the sheet interval. When receiving the instruction, the controller **20** controls operation of the optical device **102**, the image forming unit **112**, and the transfer unit **122** of the image forming apparatus **100** so as to set the interval between transfer media on which the printing images **220** are transferred to a predetermined interval or longer.

For example, the sheet interval may be controlled based on the size of the transfer medium (printing sheet) in the sub-scanning direction on which the printing image **220** is transferred, based on the output of the detection sensor that detects a leading end position of the transfer medium and that is disposed at a predetermined position in the image forming apparatus **100**, and based on the conveying speed of the transfer material.

At Step S**113**, the CPU **10** increases the sheet interval and forms the test pattern group in the area of the sheet interval on the intermediate transfer belt **114**. For example, as explained above with reference to FIG. **10**, the CPU **10** forms the test pattern groups at positions corresponding to the sensors **115***a*, **115***b*, and **115***c*. At this time, the CPU **10** controls the length of the sheet interval so that at least one test pattern group can be formed in the sub-scanning direction and a correction value calculation process for adjusting the image formation condition based on the detection result can be finished after detection of the test pattern group is completed. The length of the sheet interval as described above is stored in the ROM **12** in advance, as device specification information on the image forming apparatus **100** for example. After the test pattern groups are formed in the area of the sheet interval on the intermediate transfer belt **114**, the process proceeds to Step S**114**.

At Step S**111**, when determining that the length of the image area in the sub-scanning direction is longer than the predetermined length, the CPU **10** causes the process to proceed to Step S**112**, and starts formation of the printing image **220** in the image area in parallel with formation of the test pattern groups corresponding to the sensors **115***a* and **115***c* on the intermediate transfer belt **114**.

At Step S**114**, the CPU **10** detects the test pattern groups based on the outputs from the sensors **115***a* and **115***c* (when the process proceeds from Step S**112** to Step S**114**) or based on the outputs from the sensors **115***a*, **115***b*, and **115***c* (when the process proceeds from Step S**113** to Step S**114**). At Step S**115**, similarly to the case explained above with reference to FIG. **5**, the amounts of color misregistration in the main-scanning direction and in the sub-scanning direction are obtained based on information on the detected test pattern groups, and various correction values area calculated based on the obtained amounts of color misregistration. After calculating the correction values, at Step S**116**, the CPU **10** reflects the correction values calculated at Step S**115** in the formation of the printing image **220** of a correction target page.

As described above, according to the modification of the embodiment, when the length of the image area in the sub-scanning direction is shorter than a predetermined length, the test pattern group is not formed in parallel to the image area, but the sheet interval is increased and the test pattern group is formed in the area of the increased sheet interval. While the throughput is reduced due to an increase in the sheet interval, it is possible to perform the color misregistration correction process and prevent a decrease in the image quality.

In the modification of the embodiment, the image area is set as an image area in which the printing image **220** is formed. However, the present invention is not limited to this example. The image area may be set as an area of a transfer medium on which the printing image **220** is transferred.

According to an embodiment of the present invention, it is possible to set image settings at an appropriate timing when a test pattern is formed outside a printing area in parallel with printing of an image.

Although the invention has been described with respect to specific embodiments for a complete and clear disclosure, the appended claims are not to be thus limited but are to be construed as embodying all modifications and alternative constructions that may occur to one skilled in the art that fairly fall within the basic teaching herein set forth.

What is claimed is:

1. An image forming apparatus comprising:

a first image forming unit configured to form toner images based on image data on a plurality of first image carriers;

a second image carrier configured to move at a desired speed and on which the toner images formed on the first image carriers by the image forming unit are transferred;

a second image forming unit configured to transfer the toner images transferred on the second image carrier onto a transfer medium that is moved at the desired speed;

a test pattern generating unit configured to generate a test pattern group with a desired length in a moving direction of the second image carrier; and

an adjusting unit configured to adjust an image formation condition for the first image forming unit using the test pattern group based on a relationship between the desired length and a length of an image area in which a print image based on the image data is formed in a sub-scanning direction corresponding to the moving direction of the second image carrier.

2. The image forming apparatus according to claim **1**, wherein when the length of the image area in the sub-scanning direction is longer than the desired length, the adjusting unit is configured to:

form the test pattern group on an outside of the image area on the second image carrier along the moving direction,

detect the test pattern group thus formed, and

adjust the image formation condition for the first image forming unit based on a detection result.

3. The image forming apparatus according to claim **1**, wherein when the length of the image area in the sub-scanning direction is equal to or shorter than the desired length, the adjusting unit is configured to:

control movement of the transfer medium so as to increase an interval between transfer media to a desired length or longer in the moving direction,

form the test pattern group between an interval from a trailing end of a transfer medium and a leading end of a next transfer medium in the moving direction,

detect the test pattern group thus formed, and

adjust the image formation condition for the first image forming unit based on a detection result.

4. The image forming apparatus according to claim **1**, wherein when the length of the image area in the sub-scanning direction is equal to or shorter than the desired length, the adjusting unit does is configured to not adjust the image formation condition based on the test pattern group.

5. The image forming apparatus according to claim **1**, wherein the image area is an area of a printing image to be formed based on the image data.

6. The image forming apparatus according to claim **1**, wherein the image area is an area of the transfer medium on which the printing image is to be transferred.

7. A method of controlling an image forming apparatus, the method comprising:

forming toner images based on image data on a plurality of first image carriers;

transferring the toner images on a second image carrier moving at a desired speed;

forming an image by transferring the toner images transferred on the second image carrier onto a transfer medium being moved at the desired speed;

generating a test pattern group with a desired length in a moving direction of the second image carrier; and

adjusting an image formation condition for formation of the toner images using the test pattern group based on a relationship between the desired length and a length of an image area in which a printing image based on the image data is formed in a sub-scanning direction corresponding to the moving direction of the second image carrier.

8. The method of claim **7**, wherein when the length of the image area in the sub-scanning direction is longer than the desired length, and the adjusting further comprises:

forming the test pattern group on an outside of the image area on the second image carrier along the moving direction,

detecting the test pattern group thus formed, and

adjusting the image formation condition for the first image forming unit based on a detection result.

9. The method of claim **7**, wherein when the length of the image area in the sub-scanning direction is equal to or shorter than the desired length, and the adjusting further comprises:

controlling movement of the transfer medium so as to increase an interval between transfer media to a desired length or longer in the moving direction,

forming the test pattern group between an interval from a trailing end of a transfer medium and a leading end of a next transfer medium in the moving direction,

detecting the test pattern group thus formed, and

adjusting the image formation condition for the first image forming unit based on a detection result.

10. The method of claim **7**, wherein when the length of the image area in the sub-scanning direction is equal to or shorter than the desired length, the image formation condition is not adjusted based on the test pattern group.

11. The method of claim **7**, wherein the image area is an area of a printing image to be formed based on the image data.

12. The method of claim **7**, wherein the image area is an area of the transfer medium on which the printing image is to be transferred.

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